Ewen, which deals with the nature and causes of the brittleness of even the purest metals at temperatures near their melting points. Mr. H. Garland, of Cairo, contributes a paper on the micro-structure of ancient Egyptian metal specimens, showing that the metastable structure of cored solid solutions has persisted through many thousands of years. Prof. Hoyt deals with the constitution of the "kalchoids," by which repellent name he denotes the alloys of zinc, tin, and copper, while Prof. Guertler, of Berlin, contributes a discussion of the relation between alloy constitution and specific volume. All the papers attain a very high standard of scientific and technical interest.

## *HYDROLOGY IN THE PACIFIC.*[1]

IT is a "far cry" to the Sandwich Islands, and equally a "far cry" to the days of Captain Cook with his intrepid crew, pioneers in the exploration of Polynesia. Many changes have taken place since the black day in 1778 when the renowned navigator came to his tragic end on the snowy sand beach of Hawaii. The modern traveller who wanders so far will find the Hawaii of to-day a fully civilised community, the streets of the principal town of which, Honolulu, besides being laid with tramways and electric mains, are so covered with a network of telephone wires as to give the impression of a huge spider's web amid the palm-trees.

The Sandwich or Hawaiian, Islands are eight in number, forming a chain about 400 miles long, distant some 2,000 miles from the North American continent and from the United States, of which they constitute a territory. The principal unit is Hawaii, which gives its name to the group, and is in area more than double any of the others. The capital lies on the island of Oahu. The industry is chiefly agricultural. Practically the whole of the exports—99 per cent.—are products of the soil (rice, sugar, taro, etc.), and of these 93 per cent. are either absolutely dependent on irrigation for growth, or require the application of water at some period or other to stimulate their development, and produce the most satisfactory yield. Such being the case, the administration and conservation of the water resources of the islands are matters of obvious and fundamental importance, in regard to which the United States Government shows no sign of neglecting its responsibilities. The volume just published is an account of the investigations made during the period 1909–11 into the conditions and factors influencing the flow and economic development of the surface waters. It is replete with statistical data and full of strange names of streams and places, the pronunciation of which (Awaawapuhi, Puuwaawaa, Kukuihaele, for instance), though no doubt musical enough when correctly rendered, seems to be beset with difficulty for the uninitiated. B. C.

## *THE RESEARCH CHEMIST AND THE TEXTILE INDUSTRY.*[2]

THE textile industry of this country shows a gross value amounting to the considerable total of 333,000,000*l.*; materials to the value of 235,000,000*l.* were used in their manufacture; and 1,253,000 persons were employed in their manipulation. The power used amounted to 1,987,000 h.p., and 77 per cent. of the firms engaged in their work made a return that they had used during the same period 8,137,000*l.* worth of coal. These figures indicate that there must be under modern conditions an ever-increasing call for research chemists in this industry. If the standard that one chemist is required for every 2000 persons employed in the textile industry were set up, there would be room for no fewer than 620 highly trained chemists, who would each be dealing with an "average gross output" of the value of more than 500,000*l.* per annum.

When it is remembered that a Continental combine in the aniline dye industry employs more than 600 chemists, the above estimate of ultimate requirements cannot be considered unreasonable. The effect of this army of chemists working in the interests of the textile industry would naturally lead to astonishing developments and to considerable improvements in detail.

The student who enters a works on the research side, after having received a university education (or having equivalent qualifications), will, undoubtedly, possess a knowledge of chemistry which will rank as an immediate asset. In a way, the college training will also have prepared him for actual working conditions by indicating their nature.

In addition to this knowledge of theory, the student will make immediate use of any experience he may have gained in ordinary analytical operations. It will often be necessary to devise new methods of analysis, or, at least, modify old ones, before they can be utilised in industrial investigation. A knowledge of the principles which underlie such work is, therefore, a very necessary equipment for the young investigator. This also involves a training which has a special value to those entering this, and most other, industries. In many cases, work will rest on the borderland of industrial research, where the actual analysis of certain products can replace actual experiment in very few cases. It is the latter which counts. The former is generally of secondary value.

The research chemist will probably enter the works at an early age. If he has finished his college course at twenty, a year or two of teaching work will do no harm. It will consolidate his knowledge of theory under the stress of imparting it to others. Better still, if it is possible to determine, at that stage, the direction of his future work, he may engage in a post-graduate course of research. The actual time of coming in contact with works conditions should not be delayed beyond the age of twenty-two years, for the mind must be capable of readily adjusting itself to industrial conditions, which are naturally different from those surrounding the student in a college laboratory.

The introduction of a time factor in its relation to cost of production will alone have a great influence. Work in the factory may be practically continuous in its operation. The young chemist will, therefore, quickly realise that he has to deal with entirely new conditions. These will at once claim his interest by reason of their novelty and importance. He will soon be engaged in the attempt to control, or modify, operations proceeding on a scale possibly measured in tons, or thousands of yards.

The raw material will enter at one end of the factory. At the other end, it will leave in a more or less "finished" state. This operation may, in some cases, take months to complete, during which time the material may be subjected to innumerable processes which may possibly modify both its physical and chemical properties. The chemist will endeavour to understand, and so control, these operations that, during transit through the works, material may receive a minimum of treatment to produce a maximum effect; for this generally means satisfactory working conditions, and low cost of production.

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[1] "Water Resources of Hawaii, 1909–11." Prepared under the direction of M. O. Leighton by W. F. Martin and C. H. Pierce. Pp. 552+11 plates +3 maps. (Washington Government Printing Office, 1913.)

[2] From lectures delivered before the Institute of Chemistry, October and November, 1913, by W. P. Dreaper.

What general effect can the successful investigator have on the methods and processes employed in work of this nature? He must aim at a position under which determining methods of working are being constantly modified in detail; or even in nature. Under the most successful conditions he may, in time, find himself working three years in advance of those who are not taking full advantage of modern methods of investigation. It is difficult for an industrial chemist to hide from his experienced rivals a process or method which can be detected in the finished product by ordinary, or even special, means. Many improvements are, however, of such a nature that they cannot be detected in this way, and then the above condition may be found to apply. In most cases this standard is a reasonable one to aim at. More than this can scarcely be expected, unless the Patent Law comes in to protect ideas and methods for a longer period. When this is realised, there is obviously no finality to work of this nature, and as a result a condition of continual change will probably be set up in the factory.

It is surprising to what an extent secret working has in some cases secured a monopoly. Especially is this so, when the effect of a process, or use of a machine is not self-evident or easily traced in the finished article. Under such conditions, and more particularly where an industry has not adopted a scientific control, a certain sequence of operations has been known to remain the monopoly of a firm, or a limited number of firms, over many years—as witness the Turkey Red industry.

Even where a close examination of the finished product might suggest, to the experienced investigator, the method of treatment employed, its presence is often overlooked or unsuspected because of difficulties in the way of identification or analysis. A slight and inexpensive change in manufacture may add 10 per cent. to the apparent value of a textile material. What this means on a large output can easily be imagined, as the ordinary net profit on manufacture may be somewhere between 20 and 35 per cent.

The research chemist is, therefore, constantly trying to improve or devise methods of investigation which will enable him to keep in touch with the work of those who, for the time being, may be regarded as his competitors; and the methods utilised to this end are based more often upon personal experience than published results. Such processes generally deal with the recognition of certain physical or chemical changes which occur when the material is subjected to tests corresponding to those in actual practice. Owing to their value to the investigator, such methods are not generally disclosed. Work in this direction, or modifications in accepted processes of analysis, and in the proper interpretation of results, are often carefully guarded, until through some change in procedure, they no longer retain their original value. Many such examples will occur to the technical chemist.

The aim of the chemist in this respect is to obtain some clue of a physical or chemical nature which will suggest to the experienced investigator the nature of superior working methods. Such methods of obtaining an insight into hitherto unknown processes or applications are of considerable value. They can only be successfully used by the investigator who has a practical knowledge of manufacture in addition to an ordinary laboratory experience. Thus, to the industrial research chemist, analysis may have a different meaning to what it has to the general consulting chemist. It is a means to an end which possibly may be the discovery of the nature of a process. Analysis is also utilised to obtain the correct working conditions of a new process, or the better control of an old one. It will be gathered from these remarks that procedure must in many cases be empirical in its nature.

The research chemist often has to watch ordinary manufacturing operations over extended periods before any plan of control or improvement can be devised. Light is sometimes thrown upon such a position by the occurrence of irregular results in the daily output, or a systematic examination of the effects produced by accidental, or predetermined, variations in working conditions. Many problems have been successfully investigated by such means. Such variations, as they occur in everyday practice, may often lead to important improvements, or even suggest new processes. Thus, the research chemist will soon realise that his right place is in the works. He will use the laboratory mainly to follow up ideas in detail.

The introduction of new methods naturally calls for an immediate re-examination of the conditions of working of existing processes. This may often secure to them an extended lease of life, as in the case of the collodion method of preparing artificial silk. In these days of costly apparatus for plant, this factor must not be lost sight of. It is the first point to consider when the chemist finds he has to deal with, and equal, the results obtained, by the introduction of a more efficient process, leading to the production of a better or cheaper product.

The successful worker must, however, go further than this. Experience indicates that important results have generally been obtained by striking out boldly in a new direction. The risk connected with such pioneer work can always be minimised by working on a moderate scale, and making sure of the details of every step as it occurs in a natural sequence. With long experience, it is sometimes possible to experiment at once on a large scale with a reasonable chance of success, but this course should never be followed by the beginner. Such conditions are comparatively rare, and generally governed by some secondary consideration, such as the prohibitive cost of new apparatus, as compared with the utilisation of that already available in the works.

In industrial research, it is sometimes more important to know what not to do than the reverse. This restraining influence must be developed equally with originality. In this, the worker will naturally be guided by instinct, which may be defined as the tempering of past experience by an untiring caution.

Once more, the young chemist may be urged to spend most of his time in the works, only working in the laboratory when some work requires systematic investigation. Many manufacturers have objected to this procedure in the past, but with tact, such opposition, where it still exists, can generally be overcome. The industrial chemist who remains in his laboratory will be hopelessly left behind in the race for progress.

It is impossible to say how far the chemist should experiment in the laboratory, or when he must carry out the necessary investigation in the works itself. In the latter case, it is well to leave such labour as does not entail exact measurement in the hands of the workman. The chemist must, however, *know how to carry on such work*, and in cases of difficulty, be able to do so under the eyes of the workman. This is sometimes a rather trying experience to the novice, but it must be faced.

Be careful, when starting experimental works, and reasonably certain that all data which can be obtained on a laboratory scale are already secured. Only then should the establishment of experimental works be attempted. Much can be done in the way of experimental plant, etc., in the laboratory with 100*l*. An experimental works will probably absorb anything between 3000*l*. and 10,000*l*. before any important results or improvements can be obtained.

It sometimes happens that preliminary operations of a seemingly innocent nature induce material changes which cause endless difficulties in subsequent treatment. These disturbing causes will be entirely overlooked if the chemist does not carry his investigations back to the raw material and examine processes on the broadest lines.

In the process of mercerising the fibre must be kept under a condition of strain during at least one part of the process; and a long staple cotton (Egyptian) must be used if the treatment is to have its maximum effect. The mere chemical operation of mercerising was, in itself, ineffective (Figs. 1 and 2).

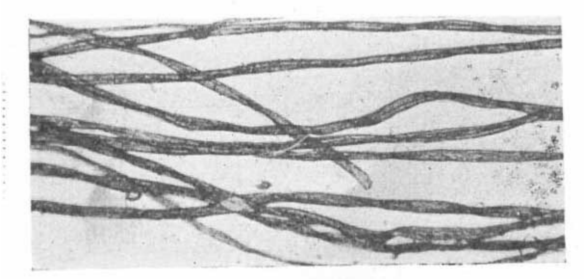

FIG. 1.—Cotton fibres (× 100).

Thus, it is evident that the modern chemist must be prepared to carry his investigation to the extreme limits of experiment, or satisfactory results will not be obtained. Also that he must extend his work beyond the realm of chemistry proper. A more general knowledge and scheme of working are necessary if the laboratory is not to remain a mere adjunct to the engineering department. The term, "chemical technologist," is one which possibly best describes the qualifications of the industrial investigator, and the knowledge he must possess.

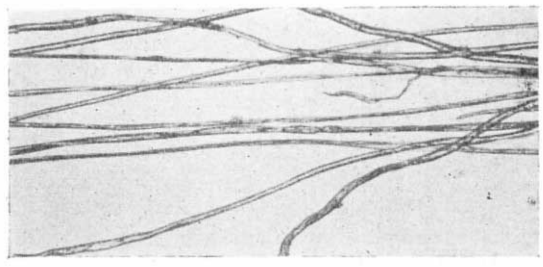

FIG. 2.—Cotton fibres after mercerising under tension (× 100).

When the student considers such processes, he will realise that the difficulties and nature of modern industrial research are closely concerned with detail. This is always so. Many problems of similar importance undoubtedly still exist in the textile industry, but these will be solved only by the trained investigator who attends to this essential point.

Thus, success is often closely associated with the art of carrying existing processes a stage further. It is with the careful working out of additional detail that it is associated.

In numberless cases, progress is only secured by following up a seemingly unimportant point. This being so, the importance of a training, be it self-inflicted or otherwise, which qualifies a man to deal with such problems is evident. In its absence, progress can only be realised by the more slowly working aid of rule-of-thumb.

The presence of this factor has given the rule-of-thumb man great power in the past, for he has at his command a wonderfully accurate instrument in the trained eye. The chemist with all his apparatus is in some cases no match for him.

The investigator, sooner or later, realises the essential value of empirical methods, and if he is wise lets the worker know that he does so. In this way, the chemist gains the worker's confidence, and the latter more clearly realises the true aim of research. Once this position is established, the workman will naturally direct attention to any variations in working which may occur, or make suggestions of distinct value. The workman has a great advantage. His mind is continuously concentrated on one operation. Thus, it often happens that only by a careful study of deviations from the normal will the research chemist be able to report progress. His aim is to explain and control, the workman's to manipulate.

Facts which are but "curiosities" to the workman, and have remained so for many years in some cases, must be carefully investigated in detail by the chemist. They often represent the starting point for improvement—a first aid to progress, when all other means have failed. Time given to such investigation is never lost, for experience in the ways of processes is a commanding asset to the industrial chemist.

Where operations are conducted on a large scale there is a greater chance of recognising such conditions. An improvement when applied on a larger scale has also a greater value. It is, therefore, better for the young chemist to get into a large works; unless he is compelled to enter a single department, in which case the greater freedom in a small works may be more valuable in spite of restricted output.

Attention may be directed to a list of the probable actions which may be involved during dyeing operations, which I advanced some time ago.

(1) A solution state of the dye within certain limits of aggregation as determined by the laws of solution.

(2) A fibre state corresponding to this state of aggregation and of a permeable nature.

(3) Localisation of dyestuff within the fibre area through surface concentration effects.

(4) Localisation of salts, acids, etc. (assistants), within the fibre area from the same cause.

(5) The direct entrance of dye aggregates by molecular migration, with subsequent reformation of aggregates within the fibre area.

(6) De-solution, due to surface concentration effects ("salting out"), or secondary attraction, between the fibre substance and the dyes.

(7) Primary or chemical action, which may play some part at this stage, and may even in some cases take the place of, or cause, de-solution phenomena.

(8) De-solution effects in the case of basic dyes, which may lead to alteration in constitution, and the production of basic salts in a state of high molecular aggregation (insoluble) within the fibre area.

In recent years, Perrin has suggested that the action of dyeing is a purely electrical phenomena, and this suggestion has been followed up in some detail by Gee and Harrison in this country.

It is only in certain cases that the chemist has a voice in the purchase of textile fibres, when certain physical or even chemical factors are recognised as being in question.

The need for such supervision may be seen in the agitation which has been actively carried on by trade associations and others concerning the methods used in South Africa in the dipping of sheep.

For some reason best known to the authorities, a sheep dip is officially recommended which consists of a mixture of slaked lime and caustic soda. The effect of this on the wool itself is sufficiently injurious, for the selling price of South African wool to be materially affected, and endless trouble introduced in subsequent manufacturing processes.

It is said that the breaking strength tests show a loss of 18 per cent. in the treated wool. Although wool buyers and English chambers of commerce have protested since 1899 against this treatment, it is still carried on, and the directions, issued in the *Government Journal of the Union of South Africa* so recently as March, 1913, still recommend its use, and give particulars of its preparation.

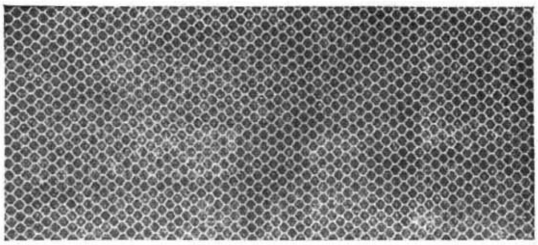

FIG. .—Artificial cellulose fabric (natural size).

This example must be the only one which can be discussed on the present occasion. Many of the methods used to determine certain differences in the nature of raw materials which count in the subsequent manufacture, as they have been noted, or even controlled, by chemists, are considered to be of a more or less secret nature.

Although we are not directly concerned with the rebleaching of goods, the use of electrolytic bleaching liquors may be strongly recommended for the laundry trade. As the sodium hypochlorite leaves the electrolyser it gives better bleaching with weak solutions than the older bleaching liquor does with strong ones. Two of the best-known types of electrolysers are those of Kellner, and that sold by Messrs. Mather and Platt. In the modern type, the original salt or brine solution passes in a serpentine course between the platinum or carbon electrodes. The salt employed in the solution is never entirely converted on grounds of economy, and care has to be taken to adjust the cost of current to that of the salt to secure economical results. Under present conditions, the cost of electrical energy must be low, but in view of the many advantages which the use of the sodium salt gives the bleacher, the new process will obviously be put to more extended use.

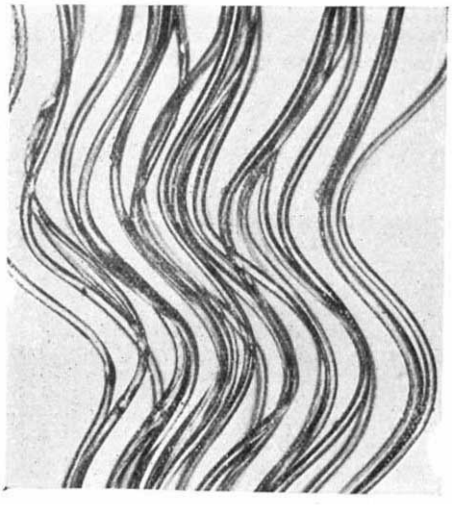

FIG. 4.—Artificial silk thread (×80).

It is a mistake, however, to imagine that the chemist's work in the textile industry is chiefly concerned with the adulteration of material and supplying the public with something which is not what it appears to be. Such work is mainly constructive, and its influence has been for good. Extraordinary results have been achieved in the last twenty years in the direction of actual improvements in manufacture as well as in the cheapening of production.

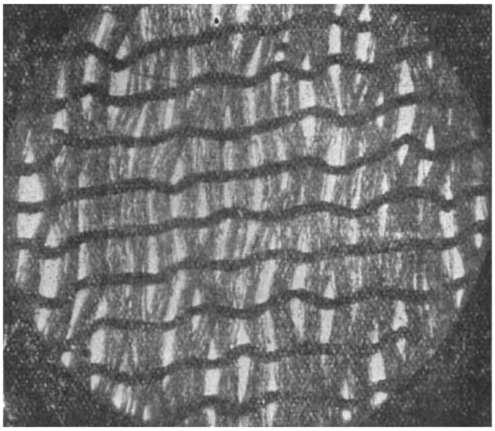

FIG. 5.—Crêpe de Chine, satisfactory finish (×30)

The manufacture of artificial fabrics direct from a solution of cellulose is a case in point (see Fig. 3), or that of artificial silk as shown in Fig. 4.

The use made of the microscope is seen in Figs. 5 and 6, where the difference in certain finishing operations is clearly disclosed and explained.

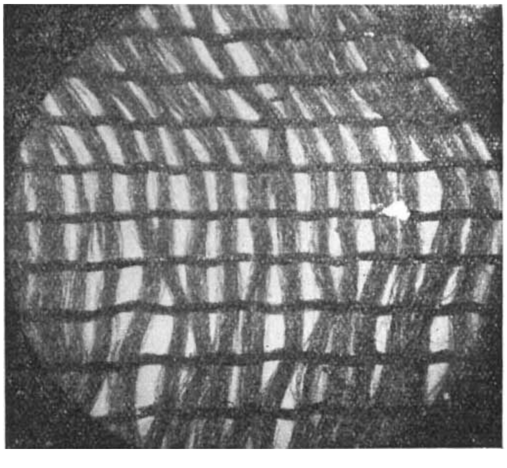

FIG. 6.—Same material, unsatisfactory finish (×30).

It will be gathered from the remarks made generally in these lectures that the influence of moisture, in its relation to the many operations of finishing adopted in this industry, is paramount. It is probably the most important influence which the investigator has to consider. The presence of moisture in a fibre gives rise to many conditions, which seem to indicate that it is present in more than one condition. This materially adds to the difficulty in determining its true influence. The fact that all the fibres take up moisture, and that this influences them in different ways, is one of the most perplexing problems met with in this industry. It will probably be many years before this matter is properly understood, or explained scientifically; but when this is achieved, light will undoubtedly be thrown on many phenomena which are so obscure to-day; and which, under present conditions, can only be dealt with on empirical lines.

The relative position of the chemist and engineer in the works has given rise to discussion in the past, and still shows signs of not being altogether understood. The opposition to the chemist which is said to exist in some quarters has probably been much overestimated. In the majority of cases the chemist obtains all the necessary aid he may require from the engineering department. As a matter of fact, the engineer always seems interested in the chemist's work. This is due, no doubt, to the different method of attack adopted by the latter, which, in itself, fully justifies the presence of the chemist in any works.

Under normal conditions the engineer frankly helps the chemist in his experimental work, and this aid is of real service in many ways. Quite apart from his previous training, the chemist will pick up a fair knowledge on the engineering side in the works, which will be particularly useful in cases where he subsequently acts as manager of a department, or even of the works itself

The chemist should be just as anxious to make friends with the engineer as with the heads of other departments; and the best way to gain experience and knowledge in this direction is to keep in touch with any new experimental plant which may be in course of erection.

In some cases, work will develop in directions which are not naturally covered by any existing department. If the operations involved are complicated, it may be better for the process to remain under his direct management or control. In this case, one or more experimental departments may, in time, be associated with the laboratory.

It is then necessary to borrow men from the engineering department, and to direct their operations. When this happens, the work of the chemist becomes still more general in its nature, and additional experience is gained in the management of men and processes.

Where experimental work is rapidly translated into full-scale operations under normal conditions, the control will pass to one of the works departments. This should be encouraged, for the chemist is then more free to continue research in any other directions which may present themselves. But he must always be ready, and able, to resume temporary control if things go wrong, or where further developments are in progress.

The evidence that a merely chemical training is insufficient is fast accumulating, and may be emphasised. The chemist may, for weeks, be working in directions which are physical or even mechanical in their nature rather than chemical. The important point is that *his method of attack is based on a past training in chemistry*; and that, because of this, it will be different from that adopted by the engineer. In this its value rests. This is the point I have tried to emphasise in these lectures. Also that success in almost every case depends upon attention to detail. Thus, an inferior mind may sometimes succeed when once a main idea has been grasped. These are the points I would especially bring to the notice of the young chemist who is entering the textile industry on the research side.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—The council of the University has appointed Prof. Charles Lapworth emeritus professor of geology in recognition of his services during his occupation of the chair of geology. The Senate recently signalised his retirement by the presentation of an address and a gift of plate, and on March 11 another presentation was made to him by a large number of his old students. Prof. Boulton was in the chair, and Dr. Walcot Gibson, who spoke on behalf of the old students, gave happy expression to the affectionate esteem in which Prof. Lapworth is held by all who have had the good fortune to come under his influence.

CAMBRIDGE.—The Observatory Syndicate has appointed Prof. A. S. Eddington, Plumian Professor of Astronomy, to be director of the observatory.

Mr. A. V. Hill has been appointed to the Humphrey Owen Jones Lectureship in Physical Chemistry.

DR. PRAFULLA CHANDRA RÂY has been appointed to the Sir Taraknath Palit professorship of chemistry in the Presidency College, Calcutta, and Mr. C. V. Raman to the Sir Taraknath Palit professorship of physics in the same institution.

IT is announced in the *London University Gazette* that a course of eight lectures on the rate of the blood-flow in man in health and disease will be given in the physiological laboratory of the University, South Kensington, by Prof. G. N. Stewart, professor of experimental medicine, Western Reserve University, Cleveland, U.S.A., at 5 p.m., on Tuesdays, from May 5 to June 23 next. The lectures are addressed to advanced students of the University and to others interested in the subject. Admission is free, without ticket.

AN article on careers for university men, by Mr. H A. Roberts, the secretary of the Appointments Board in connection with the University of Cambridge, contributed to the *Cambridge Magazine* in 1912, has been issued in pamphlet form by Messrs. Bowes and Bowes, of Cambridge, at the price of 6*d.* net. The account given of the work of the Appointments Board at Cambridge shows the usefulness of such an agency in bringing together employers of labour and university men who desire appointments. Graduates will find invaluable the information here brought together as to public posts open to suitable university men, and the facts as to the salaries to be expected at the beginning of a career should save much disillusionment later.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, March 12.—Sir William Crookes, president, in the chair.—Sir James **Stirling**: Note on a functional equation employed by Sir George Stokes. —Prof. J. C. **McLennan** and A. R. **McLeod**: The mercury green line $\lambda=5461$ as resolved by glass and quartz Lummer plates and on its Zeeman components. —H. **Hartley**: The electrical condition of a gold surface during the absorption of gases and their catalytic combustion. At the suggestion of Prof. W. A. Bone, the author has carried out experiments on the electrical conditions of a gold surface during its absorption of hydrogen, carbon monoxide, and oxygen, respectively, at temperatures between 300° and 400°, in order to establish certain data relative to surface combustion phenomena. The results have proved (1)